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Creel, Escapement, and Stock Statistics for Coho Salmon on the Little Susitna River, Alaska, During 1992

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Allen E. Bingham

September 1993

Alaska Department of Fish and Game

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ABSTRACT

Coho salmon *Oncorhynchus kisutch* returns to the Little Susitna River were assessed with a creel survey to estimate sport harvest by boat anglers and a weir to estimate spawning escapement. Creel surveys were conducted at the Burma Road boat landing from 16 July through 2 September 1992 to estimate the effort for and the catch and harvest of coho salmon by boat anglers in the sport fishery. An estimated 8,739 coho salmon were harvested and an additional 3,048 coho salmon were caught and released during 42,945 boat angler-hours of effort. Harvested coho salmon were of age 1.1 and 2.1 in similar proportions. The contribution of hatchery-produced coho salmon to the sport harvest and escapement past the weir was estimated to be 17% and 11.5%, respectively. Returning hatchery coho salmon originated from 1991 smolt releases in Nancy Lake and in the mainstem Little Susitna River at Houston, Alaska. Small numbers of coho salmon also returned from a 1990 Little Susitna River drainage smolt release and from a smolt release into the Knik Arm, Cook Inlet drainage of Fish Creek.

A total of 29,223 coho salmon were estimated in the Little Susitna River during 1992. The actual inriver return, however, was somewhat greater than 29,223 because of the unsurveyed harvest by shore anglers and by boat anglers who exit the fishery through the Port of Anchorage. Hatchery releases of Little Susitna origin contributed an estimated harvest of 1,355 coho salmon to the mixed-stock commercial fisheries of northern Cook Inlet. A total of 8,739 coho salmon were harvested in the boat angler sport fishery: 8,401 fish below the weir and 338 fish above the weir. Spawning escapement was estimated at 20,844 fish. Coho salmon are rarely observed to spawn downstream of the weir. Inriver exploitation by the boat angler sport fishery was estimated at 29%.

KEY WORDS: coho salmon, *Oncorhynchus kisutch*, creel survey, escapement, age, sex, length, sport effort, sport harvest, sport catch, hatchery contribution, Little Susitna River, smolt, stocking, weir, hook and release mortality.

INTRODUCTION

The Little Susitna River (Figure 1) has had the highest sport fishery effort in the Matanuska-Susitna Valley since 1981 and currently supports the second largest freshwater fishery for coho salmon *Oncorhynchus kisutch* in Alaska (Mills 1979-1992). Road access to the lower reaches of the Little Susitna River improved with agricultural development in the area during the early 1980s. The harvest of, and corresponding fishing effort for, coho salmon in the lower 60 km of the Little Susitna River also increased in step with improvements in access. In response to the increases in harvest, the Little Susitna River has been stocked annually with coho salmon beginning in 1982 (ADF&G 1981, Chlupach 1989).

The Alaska Department of Fish and Game (ADF&G), Division of Sport Fish, began an annual creel survey of the sport fishery for coho salmon in the Little Susitna River in 1981. An annual life-history study of coho salmon in the Little Susitna River was begun in 1982. As part of this study, a weir was constructed in the Little Susitna River to estimate the escapements of coho salmon. This weir was initially operated in 1986 and has been operated annually since 1988. A coho salmon management plan was adopted in 1990 and implemented in 1991. This management plan defines an escapement goal of 7,500 nonhatchery coho salmon for the Little Susitna River upstream of the Parks Highway bridge at river kilometer (rkm) 112 (ADF&G 1992). In this report, nonhatchery coho salmon are coho salmon that can not be identified to a specific release of hatchery fish based on marked to unmarked ratios or tagging information. The creel surveys and life history studies are summarized in a series of annual "Federal Aid in Sport Fish Restoration" reports published by ADF&G.

Data collected during this project are used to refine the management plan for hatchery and nonhatchery stocks of Little Susitna River coho salmon. It insures the escapement goal of 7,500 nonhatchery coho salmon is attained.

Data collected during this project also aid in assessing the stocking program. The stocking program has contributed up to 75% (estimated 10,613 fish) of the sport harvest (1989) and an inestimable number of additional angler-days to the sport fishery. Timely harvest, effort, and escapement information allowed for maximum use of returning hatchery stock by the angling public. This program also optimized recreational opportunity and social and economic benefits to the citizens of Alaska.

The specific objectives for the 1992 portion of this evaluation were to:

1. Estimate the angling effort for and the catch and harvest of coho salmon above and below the weir at rkm 52 of the Little Susitna River by boat anglers exiting the fishery at Burma Road from 16 July through 2 September 1992 by 7-day periods, such that the early season (16 July to 5 August) and late season effort, catch, and harvest estimates are within ± 30% (for the early season) and ± 15% (for the late season) of the true values 90% of the time.

2. Estimate the age and sex compositions of the coho salmon harvested by the boat anglers exiting at Burma Road during the 16 July through

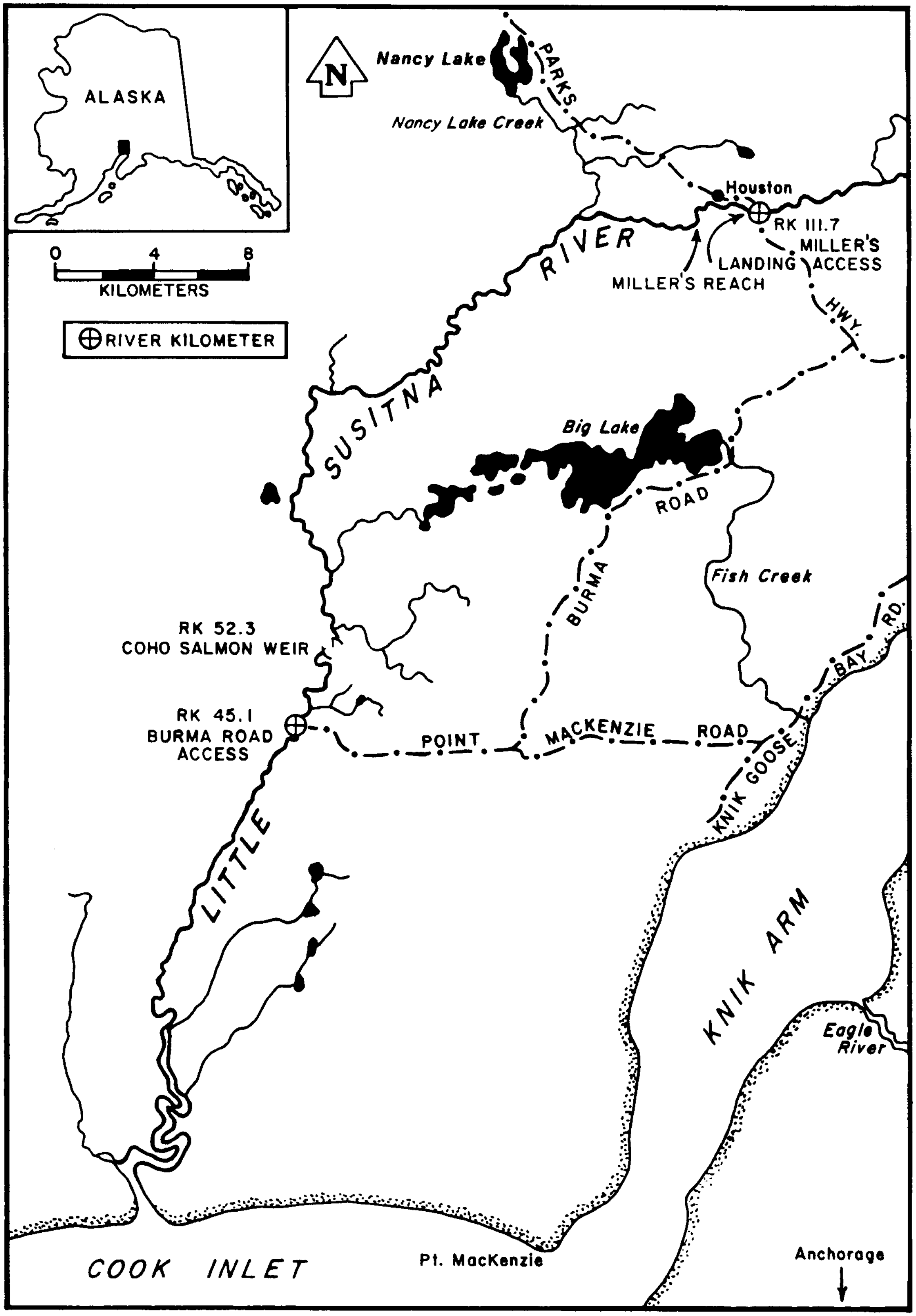

Figure 1. Little Susitna River study area.

2 September 1992 period; such that the estimated proportions by age class are within ± 5 percentage points of the true proportions 90% of the time.

3. Estimate the contribution of stocked coho salmon to the sport fishery of boat anglers exiting at Burma Road from 16 July through 2 September 1992 by 7-day periods, such that the total seasonal estimated contribution is within ± 20% of the true contribution 90% of the time <u>and</u> such that each 7-day period estimate is within either ± 150 fish or ± 50% of the true value 90% of the time.

4. Census the 1992 escapement of coho salmon in Little Susitna River past rkm 52.

5. Estimate the age and sex compositions of the coho salmon escapement past rkm 52, such that the estimated proportions by age class are within ± 5 percentage points of the true proportions 90% of the time.

6. Estimate the contribution of stocked coho salmon to the escapement past rkm 52 by 7-day periods, such that the total seasonal estimated contribution is within ± 15% of the true contribution 90% of the time <u>and</u> such that each 7-day period estimate is within either ± 150 fish or ± 50% of the true value 90% of the time.

The results of the 1992 program associated with these objectives are summarized in this report. Recommendations for future program planning are also developed.

METHODS

<u>Creel Survey Design</u>

Approximately 113 km of the Little Susitna River were open by regulation to salmon fishing during 1992 (ADF&G 1992)[1]. There were four defined access points to the fishery: (1) the Burma Road boat launch at rkm 45.1, (2) the boat launch at Miller's Landing in the city of Houston at rkm 111.7, (3) Miller's Reach at rkm 107.0, and (4) the Port of Anchorage (in the Municipality of Anchorage).

Previous research (Bartlett and Vincent-Lang 1989, Bartlett and Sonnichsen 1990, Bartlett and Bingham 1991) has shown that 80% to 90% of the catch and harvest for anglers exiting at Burma Road has been taken by boat anglers who represented 70% to 80% of the effort during fisheries for coho salmon. Boat anglers were defined as anglers who accessed their fishing site via a boat. This includes anglers who used a boat to travel to a fishing site but fished from shore once they reached the site. All the access sites were not surveyed, and because the large majority of the effort was by boat anglers, a

[1] A 458 meter reach of river was closed immediately downstream of the weir, and a 92 meter reach immediately upstream of the weir (rkm 52) was closed by emergency order.

stratified-random, three-stage, direct-expansion creel survey was conducted to estimate angler effort in hours, and the coho salmon catch and harvest of only boat anglers who exit the sport fishery through the Burma Road boat landing.

The survey at Burma Road began on Tuesday, 16 July and continued through Monday, 2 September. The survey was primarily stratified into 7-day periods. The four periods in which the major portion of the effort and harvest were anticipated (30 July through 26 August) were further divided into 5 weekday days (Tuesday, Wednesday, Thursday, Friday, and Monday) and 2 weekend days (Saturday, and Sunday) for a total of eight weekend and weekday strata during this period. The division of strata in 7-day increments was necessary to coincide with the coho management plan which required a change in the coho salmon bag limit from one to three coho salmon beginning on 6 August, and to obtain estimates on a timely basis for inseason management decisions. Stratification by type of day (weekday versus weekend) within the anticipated peak strata was primarily directed at reducing bias within (and among) these 7-day periods, and secondarily at increasing the precision of our estimates, since the variance components associated with the survey were different between these two day types. The strata definitions, along with pertinent sampling information for the Burma Road boat creel survey, are summarized in Appendix A1.

As noted, the survey was of a three-stage design, with the first stage being days; the second stage units were periods within days; and the third stage units were anglers within sampled periods. The length of the fishing day and the number of the daily periods changed with the decreasing length of daylight hours as the season progressed. The daily periods are presented in Appendix A2.

The survey schedule was designed to sample a maximum amount of time within the creel clerk's work-hours during the anticipated peak of effort and harvest. During these strata (30 July through 26 August), all weekdays and weekends were surveyed. During the first three strata (16 July through 5 August) and last stratum (27 August through 2 September) four days were randomly sampled without replacement (WOR) from each 7-day stratum. During the sixth of the seven 7-day strata (20 August through 26 August), 5 days were randomly sampled WOR. In addition to the days not sampled within these strata, zero, one or two days were selected to inspect the harvest for adipose finclipped fish.

Two or three sample periods during each day were selected at random WOR and sampled. All boat anglers were interviewed as they exited the Burma Road access location, and as such, the third-stage sampling units were censused (and the design collapsed to a two-stage survey).

Creel Survey Data Collection

A standard Alaska Department of Fish and Game, short interview creel survey form was used to record the interview information from completed-trip boat anglers departing through the Burma Road boat landing. The following questions were asked of each interviewed boat angler:

1. the total time the angler fished;
2. the number and species of fish harvested (kept);
3. the number and species of fish released;

4. whether the angler had completed his/her trip (completed-trip interview) or not (incompleted-trip interview); and
5. whether the angler fished upstream or downstream of the weir.

Creel survey personnel maintained daily summaries of the number of anglers interviewed, the total daily effort in hours, and the number of coho salmon harvested and caught. Since all anglers were interviewed then the number of anglers interviewed is used as the count of anglers exiting the fishery (a "dummy" angler count data file is created for each date and period sampled for use by the analyses programs, see Appendix F).

Creel Survey Data Analysis

Angler interview and count mark-sense forms were visually checked for errors and corrected as necessary. Corrected forms were sent to Research and Technical Services (RTS) for optical scanning. Resultant data files and summary printouts were checked for errors and corrected as necessary. Corrected data files were sent back to RTS for archiving. Angler count and interview data files were then processed by Division of Sport Fish's creel survey computer programs and analyzed according to the procedures outlined below (archived data files and analysis programs are listed in Appendix F):

Angler Effort, Catch, and Harvest:

Procedures used to estimate effort, catch, and harvest for the Burma Road access site in 1992 were the same as those used in the 1990 and 1991 boat angler survey. The procedures are outlined in Appendix A3 and represent a three-stage direct expansion estimation approach. This approach involved the direct expansion of mean effort, catch, and harvest of anglers sampled within a period by the number of anglers exiting the fishery during the sampled period. Then the mean values of effort, catch, and harvest across periods sampled within each sampled day were expanded by the total number of periods in the day to obtain estimates of the daily statistics. Stratum estimates of these statistics were calculated by expanding mean values across days within each stratum by the total number of days within a stratum. Across strata estimates were obtained by summing the individual stratum estimates. Since all anglers counted were interviewed, the design collapses to a 2-stage design; however, estimates were still obtained in a three-stage manner (and were equivalent).

Assumptions:

Assumptions necessary for the unbiased point and variance estimates of angler effort, catch, and harvest obtained by the procedures outlined above and in Appendix A3 include the following:

1. interviewed boat anglers were representative of the total boat angler population exiting at Burma Road;

2. interviewed boat anglers accurately reported their hours of fishing effort and the number of coho salmon caught and the number of coho salmon released; and

3. no significant fishing effort occurred during the hours not included in the fishing day.

With regard to assumption 1, boat anglers interviewed at the Burma Road survey site were assumed representative of all boat anglers exiting the fishery through that site only. With regard to assumption 2, not all boat anglers were able to remember the hours of fishing effort and tended to report a number of hours somewhere between the length of the trip and the actual number of hours spent fishing on the trip. Assumption 3 was in general valid because boats were generally not navigated on the river during hours of darkness.

Weir Census Design and Data Collection

A weir program was used to census the escapement of coho salmon past rkm 52. A floating weir was placed across the Little Susitna River at rkm 52 from 24 July through 13 September (Figure 1). The weir was a resistance-board design modified to pass boats. A live trap with a V-shaped entrance was placed on the upstream side of the weir. Spacing between the weir and live-trap pickets was 38 millimeters. This spacing allowed for the complete census of all but the smallest 0-ocean (jack) coho salmon. Information collected daily at the weir is listed in Appendix B.

Weir Data Analysis

Daily summaries of information collected at the weir were forwarded by telephone to the area office each weekday. Daily escapement data were entered into a computer spreadsheet for general summaries.

Biological Sampling Design and Data Collection

Age and sex compositions of coho salmon were estimated for the harvest by sampling during the creel survey, and for the escapement by sampling at the weir. Additionally, mean length at age by sex was also estimated for both the creel survey and escapement.

Hatchery coho salmon from smolt releases are almost exclusively age 1.1, while nonhatchery coho salmon and those from hatchery fry releases may be ages 1.1, 2.1, or 3.1. Occasionally 0-ocean jacks of hatchery or nonhatchery origin are also encountered in the harvest. Age compositions may change over time as the contribution of hatchery and nonhatchery fish to the harvest or escapement change or the age composition of the nonhatchery stock varies. A minimum sample of 66 fish per 7-day period (462 fish total) both in the harvest and at the weir was attempted. When sampling fish at the weir, the sample was obtained by allowing the live trap to fill with the approximate number of coho salmon needed for the sample (10-15 fish per day). The entire contents of the trap were then sampled to eliminate selection or behavior biases inherent in subsampling fish.

Three scales for aging were collected from the left side of each sampled fish, two rows above the lateral line and on the diagonal row downward from the posterior insertion of the dorsal fin (Scarnecchia 1979). Scales were mounted on gum cards and impressed in cellulose acetate as described in Clutter and Whitesel (1956). Age determinations were made using a microfiche reader and recorded by the European method.

Sex composition of coho salmon has been shown to change over time inseason and between years. The sex of those fish randomly selected for age composition was recorded. Sex ratios were estimated on a 7-day stratum basis to coincide with the creel survey periods. Coho salmon were sexed based on external characteristics.

The mean length of fish by age and sex composition may change over time and with the introduction of hatchery releases. The mean lengths by sex of age-1.1 and -2.1 fish in the 1992 harvest were compared to the mean lengths by sex of age-1.1 and -2.1 fish from the 1983 harvest (Bentz 1984) to estimate any differences in mean length between returns of fish without hatchery contribution (1983) and with hatchery contribution (1992). The two age-2.0 males in the 1992 harvest sample were not included in this analysis. Only samples from the harvests were compared as samples from the 1983 escapement were not reported.

<u>Biological Sampling Data Analysis</u>

Estimates of sex and age composition (proportion), for the subsampled coho salmon were calculated for each stratum for the creel survey and at the weir. Information collected from the contiguous sets of sampling strata was grouped and chi-squared contingency table tests were conducted to evaluate the similarity of age compositions across grouped strata. Similarly, the proportion sampled of the estimated coho salmon harvested within each stratum was evaluated for adherence to proportional sampling. Since the age compositions did differ appreciably among strata and proportional sampling was not indicated, estimates of age composition (proportion) for the subsampled coho salmon were calculated for each stratum separately and then summed across all strata to estimate the total number of fish in the harvest or escapement in each age class. Complete details of the estimation procedure are presented in Appendix C.

The mean length by sex of coho salmon from the 1983 harvest was reported with the standard deviation. The standard deviation of the 1983 harvest was converted to standard error by dividing by the square root of the sample size. The means were compared using a two tailed t-test (at $\alpha = 0.10$).

<u>Hatchery Contribution Design and Data Collection</u>

The majority of the 1992 inriver return of hatchery coho salmon originated from two major hatchery releases in the Little Susitna River drainage at Nancy Lake and Houston (Appendix D1). Approximately 277,800 coho salmon smolt, of which approximately 46,400 (17%) were tagged with a coded wire tag (CWT) and had their adipose fin removed, were released in the Little Susitna River drainage in 1991. To estimate the contribution of these stocked fish to the estimated 1992 sport harvest and the censused escapement (at rkm 52), all coho salmon harvested by boat anglers checked in the creel survey, and a portion of those passing upstream through the weir, were inspected for a missing adipose fin. A small number of coho salmon from a 1990 smolt release in the Little Susitna River at Houston and a 1991 smolt release in Fish Creek, a small creek draining into the Knik Arm of Cook Inlet approximately 40 shoreline kilometers northeast of the Little Susitna River mouth, also contributed to the harvest.

Tallies by day of both the number of fish examined and the number of fish with a missing adipose fin were kept. Heads were collected from whole harvested fish observed with a missing adipose fin.

Inseason estimation of the hatchery produced coho salmon passing upstream of rkm 52 was required to project the escapement of 7,500 nonhatchery coho salmon to the spawning grounds upstream of the Parks Highway Bridge (rkm 112) as provided by the coho salmon management plan. To project this escapement at the weir, an average expected harvest of 500 nonhatchery coho salmon upstream of the weir (Bartlett and Vincent-Lang 1989, Bartlett and Sonnichsen 1990, Bartlett and Bingham 1991) was added to the estimation of nonhatchery coho salmon passing upstream of the weir. Therefore, a goal of an estimated 8,000 nonhatchery coho salmon was established to pass upstream of the weir to satisfy escapement requirements. Nonhatchery coho salmon were estimated for each 7-day stratum by subtracting the estimated hatchery contribution from the total escapement.

Hatchery Contribution Data Analysis

Contribution to the Harvest:

The sampling procedure was essentially the same as the creel survey program, with the additional sampling stage associated with inspecting each angler's creel. All fish in a sampled angler's creel were inspected, and as such this final sampling stage was censused. The multi-stage nature of the sampling design was not utilized in estimating the contributions in that it was assumed that the rate of contribution to the fishery did not vary substantially among sampling units within each stratum (or combined strata). Estimates of the contribution by CWT lot to each stratum of the fishery (or possibly within combined strata) were calculated according to the procedures outlined in Appendix D2.

These procedures essentially followed the approach outlined by Clark and Bernard (1987). The estimate of the variance and the standard error of these estimates were obtained via the bootstrap estimation approach (Efron 1982), since in the sampling program, the total harvest was estimated, via the creel survey. The equations presented in Clark and Bernard (1987) could not be used to estimate these variances due to the presence of sampling error in the estimates of total harvest. Estimates were obtained either separately for each stratum, or by select combinations of strata. Combination of strata could occur if either the relative contribution rate of each CWT release lot did not vary among the strata to be combined or if the sampling fractions (number inspected for adipose finclips versus the estimated harvest) were similar among the strata to be combined. As such, within any 7-day period with weekday versus weekend stratification, the contribution rate would be expected to be similar and might be combined prior to calculation of contributions. Combination of strata was only necessary (prior to data analysis) if insufficient numbers of coho salmon were inspected for adipose finclips or insufficient tags were decoded (regardless of tag code). Contingency table analyses comparing the sampling fractions among strata and comparing the marked (adipose finclipped) to unmarked ratios among strata were used to determine if strata could be combined.

Contribution to the Escapement:

Similar to the creel survey, a sample of coho salmon passing the weir was inspected for missing adipose fins. However, coho salmon observed at the weir were not sacrificed to collect the tag. Since the tagging fractions were similar between the two releases of hatchery fish that were expected to return in 1992, and since previous studies indicated that the two release locations did not appear to differ substantially in terms of return strength, then the overall combined tagging ratio of 0.1669 was used to estimate the hatchery contribution to the escapement.

The hatchery contribution to the escapement at the weir was estimated by the procedures outlined in Clark and Bernard (1987; equations [10], [14], and [15]). The procedures of Clark and Bernard (1987) could be followed in this case since the total escapement was not estimated, but was known. Chi-squared contingency table analyses were conducted on the weir data base to determine if contiguous 7-day periods could be combined if necessary (due to insufficient numbers sampled or adipose finclips observed). In applying the procedures in Clark and Bernard, tag loss was estimated by subtracting the total percent of shed tags, as reported by the hatchery, from the number of clips observed in each 7-day stratum at the weir.

Smolt Stocking

In May 1992, approximately 312,900 coho salmon smolt were released into the Little Susitna River drainage. Of the total released, approximately 158,500, 23.4 gram smolt were released in Nancy Lake near the outlet of Lilly Creek and approximately 154,500, 24.1 gram smolt were released in the mainstem river at Miller's Landing near Houston (Figure 1). Indicators of smolting, including behavior, color change, and blood sodium concentration, signaled the release.

The smolt originated from 590,000 eggs collected during a 1990 egg take in Nancy Lake. Embryos were incubated at the Fort Richardson hatchery. As fry, the smolt were divided into two groups and reared in separate raceways using standard hatchery techniques (ADF&G 1983).

Approximately 21,598 smolts (14%) of the Nancy Lake release and approximately 21,844 smolts (14%) of the Houston release were implanted with a coded wire tag and marked by clipping the adipose fin. Tag code 31-20-06 was assigned to the Nancy Lake release and tag code 31-20-07 to the Houston release. To determine CWT retention during tagging, 200 smolt tagged the previous day were scanned for a CWT during each day of the tagging operation. The final percent tag retention was determined from a 200 smolt sample from each tag code just prior to release. Tag loss prior to release was estimated to be approximately 11% in both releases.

Egg Collection

Approximately 833,000 eggs were collected from 170 female coho salmon in Nancy Lake by seining near the mouth of Lilly Creek in late September 1992. Ripeness was determined by physical examination of the fish. Ripe fish were killed by striking them on the head with a club. Milt from ten males was combined with eggs from five females in a five gallon plastic bucket. Water from Nancy Lake sufficient to cover the eggs was added to initiate fertilization. After one minute in the fertilization water, the eggs were rinsed, transferred to plastic bags, and placed in coolers to water harden for 45 to 90 minutes. The eggs were then iced, transported by truck to Fort Richardson hatchery, and placed into incubators.

All coho salmon captured in the egg take were examined for a missing adipose fin. Heads were collected from all fish with a missing adipose fin and sent to the ADF&G tag lab in Juneau, Alaska for decoding. Egg collection field information was recorded in "Rite in Rain" notebooks and transferred to standard Fisheries Rehabilitation, Enhancement and Development (FRED) Division hatchery production forms before being transported to the hatchery. Smolt from this egg collection are scheduled to be reared in the Fort Richardson hatchery and released into the Little Susitna River during the spring of 1994. They will return as adults during the summer of 1995.

RESULTS

Creel Statistics

A direct expansion creel survey was used to estimate the boat angler effort (in angler-hours) at the Burma Road access point to the Little Susitna River coho salmon sport fishery.

The number of boat anglers exiting the fishery at Burma Road during a surveyed period ranged from 0 to 148. Periods later in the fishing day were generally the busiest with respect to the number of anglers departing the fishery.

The total estimated effort during the coho salmon survey for all boat anglers exiting the sport fishery at Burma Road was 42,945 angler-hours (SE = 3,457) (Table 1). An estimated 1,300 (SE = 261) hours of this effort were spent fishing upstream of the weir (rkm 52). Hours of angler effort by 7-day periods for all boat anglers exiting the fishery at Burma Road ranged from 991 to 16,312. The highest estimated effort occurred from 6 August through 12 August. The lowest estimated 7-day effort was during the period from 27 August through 2 September.

The total estimated harvest of coho salmon by boat anglers exiting the fishery at Burma Road was 8,739 fish (SE = 674) (Table 2). An estimated 338 (SE = 58) coho salmon were harvested upstream of the weir (rkm 52). The estimated harvest of coho salmon by 7-day period for all boat anglers exiting the fishery at Burma Road ranged from 144 to 4,046. The highest number of fish for an estimated 7-day period was from 6 August through 12 August. The lowest estimated 7-day harvest was during the period from 16 July through 22 July.

The total estimated catch of coho salmon by boat anglers exiting the fishery at Burma Road was 11,787 fish (SE = 992) (Table 2). An estimated 470 (SE = 82) of these were caught upstream of the weir. The estimated catch of coho salmon by 7-day period for all boat anglers exiting the fishery at Burma Road ranged from 278 to 4,381. The highest number of fish estimated for a 7-day period was during the stratum from 6 August through 12 August. The lowest estimated 7-day catch was during the period from 27 August through 2 September.

Table 1. Estimated effort by boat anglers exiting the Little Susitna River coho salmon sport fishery through the Burma Road access in 1992.

Date	Estimated Effort (angler-hours)	SE	Relative Precision (α = 0.10)	90% Confidence Interval
716-722	1,111	291	43%	633 - 1,590
723-729	4,102	1,261	51%	2,027 - 6,176
730-805	9,068	2,089	38%	5,632 - 12,504
Early Total[a]	14,281	2,457	28%	10,238 - 18,323
806-812	16,312	1,485	15%	13,869 - 18,755
813-819	7,900	1,589	33%	5,286 - 10,514
820-826	3,461	1,014	48%	1,793 - 5,129
827-902	991	392	65%	346 - 1,635
Late Total[a]	28,664	2,431	14%	26,233 - 31,095
Total	42,945	3,457	13%	37,258 - 48,631

[a] See objective number 1 for definition of terms.

Table 2. Estimated harvest and catch by boat anglers exiting the Little Susitna River coho salmon sport fishery through the Burma Road access in 1992.

Date	Estimated Harvest	SE	Relative Precision (α = 0.10)	90% Confidence Interval	Estimated Catch	SE	Relative Precision (α = 0.10)	90% Confidence Interval
716-722	144	40	45%	79 - 209	306	140	75%	75 - 537
723-729	696	183	43%	395 - 997	1,658	419	42%	969 - 2,347
730-805	1,241	231	31%	860 - 1,622	2,627	611	38%	1,621 - 3,633
Early Total[a]	2,081	298	24%	1,591 - 2,571	4,591	754	27%	3,351 - 5,832
806-812	4,046	399	16%	3,390 - 4,702	4,381	423	16%	3,686 - 5,076
813-819	1,700	398	39%	1,045 - 2,355	1,820	426	38%	1,120 - 2,520
820-826	639	179	46%	344 - 934	717	200	46%	388 - 1,046
827-902	273	126	76%	65 - 481	278	128	76%	67 - 489
Late Total[a]	6,658	605	15%	5,663 - 7,653	7,196	645	15%	6,135 - 8,257
Total	8,739	674	13%	7,630 - 9,848	11,787	992	14%	10,155 - 13,419

[a] See objective number 1 for definition of terms.

Overall, boat anglers exiting the coho salmon sport fishery through Burma Road released about 26% of the coho salmon they had caught (Table 3). Based on the 69% estimated mortality rate reported by Vincent-Lang et al. (*In press*) approximately 18% (2,103 fish) of the 11,787 coho salmon caught was estimated to have succumbed to hook and release mortality. The total mortality (hook and release mortality plus the harvest) was estimated to be 92% of the catch.

Escapement Statistics

From 24 July through 13 September, 21,182 coho salmon, 8,342 chum salmon *O. keta*, 4,827 sockeye salmon *O. nerka*, and 27,066 pink salmon *O. gorbuscha* were passed through the weir at rkm 52 (Appendix E). Thirty-five chinook salmon *O. tshawytscha* were also passed but the count for this species was incomplete because the majority of the return passed the weir site prior to weir installation.

The counted escapement of coho salmon through the weir adjusted for the estimated harvest by sport anglers fishing upstream of the weir and exiting the sport fishery through Burma Road was 20,844 fish (SE = 58). A small but unknown number of coho salmon are also harvested near the mouth of Nancy Lake Creek. Fifty percent of the coho salmon passed through the weir (10,591 fish) on 19 August (Figure 2).

Coho salmon escapement through the weir in 1992, adjusted for the upstream harvest component, represents almost the entire escapement to the Little Susitna River. Inspection of the river under excellent visibility conditions downstream of the weir one day prior to its removal on 13 September indicated only a few coho salmon holding in areas of the river which normally contain hundreds of fish. It is doubtful that significant numbers of fish passed the weir before or after it was removed. The unestimated harvest upstream of the weir is also believed minimal and coho salmon are rarely observed to spawn downstream of the weir.

Size, Sex, and Age Compositions

A total of 471 coho salmon from the Burma Road sport harvest (5% of the estimated harvest) was sexed and aged. Females and males represented 42% (SE = 4%) and 58% (SE = 4%) of the estimated harvest, respectively (Table 4). Age-1.1 coho salmon were the most abundant age group comprising 72% (SE = 3%) of the estimated harvest. The remaining harvest was comprised of age groups 2.1 (28%, SE = 3%) and 2.0 (<0.5%, SE = <0.5%), in descending order.

A total of 448 coho salmon (2% of the total escapement) was sampled at the weir for sex, lengths, and ages. Females and males represented 44% (SE = 3%) and 56% (SE = 3%) of the escapement, respectively (Table 5). Age 2.1 (52%, SE = 3%) and 1.1 (48%, SE = 3) were the only age groups in the escapement.

The age composition of fish sampled in the Burma Road harvest and escapement samples were significantly different ($\chi^2 = 25.2$ with 1 degree of freedom, $P < 0.0001$, $\alpha = 0.10$). Age-1.1 fish dominated the harvest and age-2.1 fish the escapement. Age-2.0 male coho salmon were only evident in the harvest samples.

Table 3. Summary of coho salmon released by boat anglers exiting the sport fishery through the Burma Road landing, 1992, with an estimate of the angling induced mortality.

					Released Fish Mortality[a]		Total Mortality[b]			
Dates	Catch	Harvest	Release	Percent Released	#fish	Percent[c]	#fish	Percent[c]	Effort[d]	Bag Limit
716-722	306	144	162	52.9%	112	36.6%	256	83.6%	1,111	1
723-729	1,658	696	962	58.0%	664	40.0%	1,360	82.0%	4,101	1
730-805	2,627	1,241	1,386	52.8%	956	36.4%	2,197	83.6%	9,068	1
806-812	4,381	4,046	335	7.6%	231	5.3%	4,277	97.6%	16,311	3
813-819	1,820	1,700	120	6.6%	83	4.6%	1,783	98.0%	7,900	3[e]
820-826	717	639	78	10.9%	54	7.5%	693	96.6%	3,461	5
827-902	278	273	5	1.8%	3	1.1%	276	99.4%	991	5
Totals	11,787	8,739	3,048	25.9%	2,103	17.8%	10,842	92.0%	42,945	

[a] Mortality of released fish estimated at 69% from Vincent-Lang et al. (*In press*).

[b] Total mortality equals estimated released fish mortality plus the harvest.

[c] Estimated percent of catch.

[d] Effort in angler-hours.

[e] Bag limit downstream of the weir (rkm 52) changed from 3 to 5 coho salmon at 0001 hours 15 August.

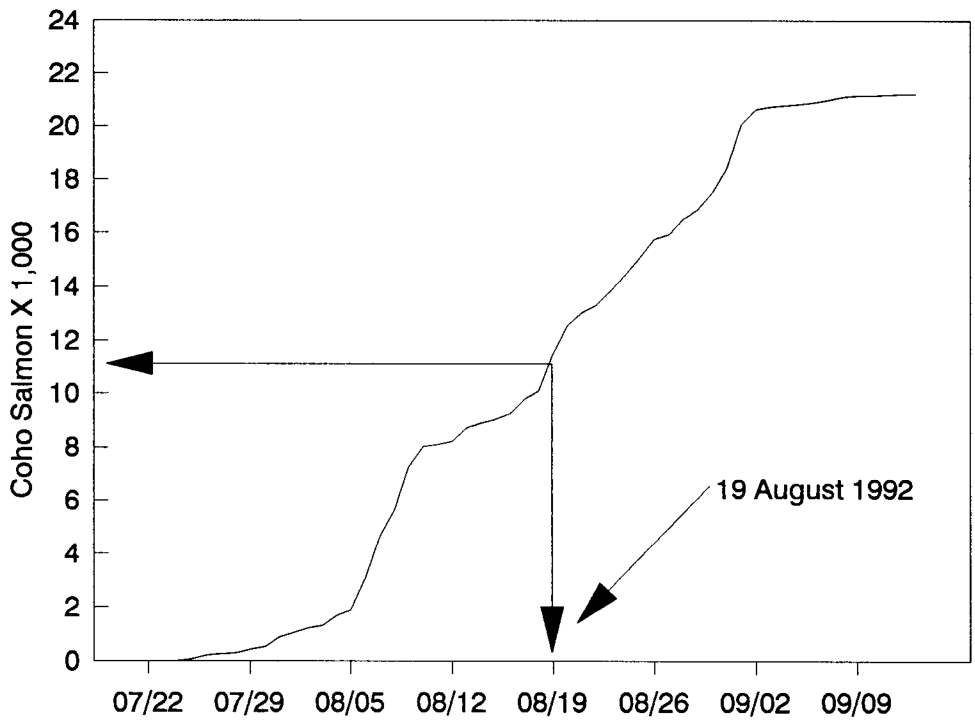

Figure 2. Cumulative escapement through the Little Susitna River weir (rkm 52) with the mid-point (50%) noted.

Table 4. Estimated sex and age composition of coho salmon from the Little Susitna River Burma Road sport fishery harvest in 1992.

	Age Group			
	1.1	2.0	2.1	Total
Females:				
Estimated Harvest	2,536		1,165	3,701
SE	290		170	336
Percent	29		13	42
SE (%)	3		2	4
Males:				
Estimated Harvest	3,766	14	1,258	5,038
SE	404	11	200	451
Percent	43	<0.5	14	58
SE (%)	4	<0.5	2	4
Sexes Combined:				
Estimated Harvest	6,302	14	2,423	8,739
SE	544	11	295	562
Percent	72	<0.5	28	100
SE (%)	3	<0.5	3	

Table 5. Estimated sex and age composition of coho salmon from the Little Susitna River escapement through the weir in 1992.

	Age Group		
	1.1	2.1	Total
Females:			
Estimated Escapement	5,420	3,850	9,271
SE	509	444	675
Percent	26	18	44
SE (%)	2	2	3
Males:			
Estimated Escapement	5,677	6,234	11,911
SE	514	526	735
Percent	27	29	56
SE (%)	2	2	3
Sexes Combined:			
Estimated Escapement	11,097	10,085	21,182
SE	579	579	0
Percent	52	48	100
SE (%)	3	3	

There was no significant difference (α = 0.10) in the sex ratio of coho salmon from the Burma Road harvest and escapement age samples (χ^2 = 0.2 with 1 degree of freedom, P = 0.647).

The mean lengths in millimeters by sex of coho salmon from the Burma Road harvest (Table 6) and from the weir (Table 7) were compared with a two-tailed t-test (α = 0.05). There were no significant differences between age-1.1 and -2.1 fish in the harvest and escapement samples with the exception of age-2.1 males which were slightly longer (a difference of 14 mm) in the escapement sample (t = 2.0, degrees of freedom = 212, P = 0.0468). Age-2.0 males were only in the harvest sample because they pass between the weir pickets and can not be captured for sampling at the weir.

The mean lengths of wild coho salmon by sex from the 1983 harvest and the mean lengths of mixed hatchery and nonhatchery coho salmon by sex from the 1992 harvest were compared with a two-tailed t-test (α = 0.05) to estimate any change in mean length that may have occurred as a result of the introduction of hatchery fish. There were no significant differences in the mean length of males (t = 1.8, degrees of freedom = 457, P = 0.0725) or females (t = 0.8, degrees of freedom = 425, P = 0.4242) between the years compared.

Hatchery Contributions

Contribution to the Sport Fishery:

Of a total of 3,834 coho salmon examined from the Burma Road sport fishery, 121 had a missing adipose fin (Table 8). Of these, 101 heads were removed and sent to the FRED Division CWT lab for processing. A total of 85 fish (84%) had CWT's present that could be decoded. Decodeable tags were recovered from four hatchery releases: a 1990 smolt release from Little Susitna brood, two 1991 smolt releases from Little Susitna brood, and one 1991 Fish Creek smolt release from Fish Creek brood. Chi-square tests comparing the estimated sport harvest by boat anglers exiting through the Burma Road landing to the number of fish examined for a missing adipose fin and the number of fish observed with a missing adipose fin within the 14 strata indicated that significant differences (α = 0.05) were present between four weekend/weekday strata. The hatchery contributions for these four strata were estimated separately and summed (with each respective variance) with the remaining strata for a total estimated hatchery contribution of 1,482 (SE = 189) fish to the sport harvest (Table 9). Based on these data, the estimated contribution of hatchery-produced coho salmon represents 17.0% of the total estimated Burma Road boat angler harvest of 8,739 fish.

Ninety-five percent of the total 1992 estimated hatchery contribution of 1,482 fish to the Burma Road boat angler sport harvest originated from the two major 1991 smolt releases at Nancy Lake and Houston. The Nancy Lake release contributed 78% and the Houston release contributed 22% of the estimated total 1,407 (SE = 182) fish contributed from these two smolt releases. The remaining 5% originated from the 1990 Houston smolt release and from the 1991 Fish Creek release.

Table 6. Mean length of coho salmon by sex and age group sampled from the Little Susitna River Burma Road sport fishery in 1992.

	Age Group		
	1.1	2.0	2.1
Females:			
Mean Length (mm)[a]	573		594
SE	3		4
Sample Size	133		72
Minimum	445		500
Maximum	650		690
Males:			
Mean Length (mm)[a]	587	288	589
SE	4	8	6
Sample Size	179	2	85
Minimum	410	280	430
Maximum	850	295	680

[a] Mid-eye to fork of tail.

Table 7. Mean length of coho salmon by sex and age group sampled from the escapement at the Little Susitna River weir in 1992.

	Age Group	
	1.1	2.1
Females:		
Mean Length (mm)[a]	577	586
SE	4	4
Sample Size	117	89
Minimum	380	470
Maximum	650	650
Males:		
Mean Length (mm)[a]	588	603
SE	5	4
Sample Size	113	129
Minimum	450	430
Maximum	670	700

[a] Mid-eye to fork of tail.

Table 8. Little Susitna River Burma Road coho salmon coded wire tag recovery summary by release and 7-day strata, 16 July through 2 September 1992.

Strata	Dates of Survey	Heads W/CWT	Dec[a] CWT	Clips[b] Obser.	Heads To Lab	Estimated Total Harvest	Variance	Number Inspected	Unique Code[c] 35	36	17	27	Total	Tagging Proportion
1	716 - 722	0	0	0	0	144	1,572.3	57					0	31-19-35 = 0.1598
2	723 - 729	4	4	4	4	696	33,527.3	209	1	1			4	31-19-36 = 0.1821
3	730 - 805	2	2	4	4	1,241	53,553.6	329	2				2	31-19-17 = 0.1476
4	806 - 812	39	39	59	47	4,046	159,094.6	2,142	28	10	1		39	31-16 27 = 0.1164
5	813 - 819	24	24	35	30	1,700	158,489.7	775	18	5		1	24	
6	820 - 826	10	10	12	10	639	32,073.8	205	6	3		1	10	
7	827 - 902	6	6	7	6	273	15,981.0	117	5	1			6	
Totals		85	85	121	101	8,379	454,292.3	3,834	62	20	1	2	85	

[a] Number of heads found to have a decodeable coded wire tag.

[b] Number of adipose finclips observed in the inspected harvest.

[c] Released at: 31-19-35 = Nancy Lake; 31-19-36 = Houston; 31-19-17 = 1990 Nancy Lake smolt; 31-16-27 = Fish Creek smolt.

Table 9. Little Susitna River Burma Road hatchery coho salmon composition point estimate summary by release and 7-day strata, 16 July through 2 September 1992.

Date	716-722		723-729		730-805		806-812		813-819		820-826		827-902		Total		
Strata	1		2		3		4		5		6		7				
Harvest	144		696		1,241		4,046		1,700		696		273		8,739		
Tag Code[a]	Contrib[b]	SE[c]	Contrib[b]	SE[c]	Contrib[b]	SE[c]	Contrib[b]	SE[c]	Contrib[b]	SE[c]	Contrib[b]	SE[c]	Contrib[b]	SE[c]	Contrib[b]	SE[c]	Relative Precision[d]
31-19-17	0	0	0	0	0	0	21	26	0	0	0	0	0	0	21	26	205%
%[e]	0		0		0		0.5		0		0		0		0.2		
31-16-27	0	0	0	0	0	0	0	0	22	26	32	35	0	0	54	43	131%
%[e]	0		0		0				1.3		5.0				0.6		
31-19-35	0	0	63	34	81	33	436	94	288	96	140	67	85	50	1,093	156	24%
%[e]	0		9.1		6.5		10.8		16.9		21.9		31.1		12.5		
31-19-36	0	0	18	17	0	0	149	53	70	33	62	36	15	17	314	70	37%
%[e]	0		2.6		0		3.7		4.1		9.7		5.5		3.6		
Total	0		81		81		606		380		234		100		1,482	189	21%
%[e]	0		11.6		6.5		15.0		22.4		36.6		36.6		17.0		

a Released at: 31-19-35 = Nancy Lake; 31-19-36 = Houston; 31-19-17 = 1990 Nancy Lake smolt; 31-16-27 = Fish Creek smolt.

b Contribution to harvest.

c Standard error.

d Relative precision in numbers of fish = (1.645 * SE)/Contribution * 100%.

e Percent of harvest.

Contribution to the Escapement:

Of a total 4,027 (19.0%) coho salmon examined from the escapement (21,182 fish) past the weir, 87 were observed to have a missing adipose fin (Table 10). Escapement through the weir, the number of coho salmon inspected, and the number of missing adipose fins observed were grouped into 7-day periods to correspond with the bag limit change from one to three coho salmon starting on 6 August. The hatchery contribution for each 7-day period was then estimated separately and summed (with the respective variances) to produce the total estimated hatchery contribution through the weir. Coho salmon at the weir were not killed to recover the CWT. Several tag codes may have been present in the escapement as indicated by the hatchery contributions to the harvest. Only the two major releases contributing to the hatchery contribution in the Burma Road boat angler sport harvest, smolt releases at Nancy Lake and Houston, were used in estimating the hatchery contribution at the weir. These releases and the number of smolt reported marked were summed for a tagging proportion of 0.1669.

Based on these data, the hatchery contribution to the 21,182 coho salmon passing through the weir was estimated to be 2,468 (SE = 279) fish or about 11.5% of the escapement.

Contribution to the Commercial Fishery:

Little Susitna River stocks of coho salmon are harvested in the mixed-stock commercial fisheries in Cook Inlet. In 1992, a northern Cook Inlet coho salmon stock assessment feasibility program was conducted by the Sport Fish Division. Coded wire tag recoveries from coho salmon fry and smolt released in northern Cook Inlet streams in 1990 and 1991, and harvested in the mixed-stock commercial fisheries of northern Cook Inlet in 1992, were used to estimate the contribution of hatchery stocks (Hoffmann and Waltemyer *In prep*).

Of a total of 20,618 coho salmon examined from the total harvest of 84,941 fish caught by the northern Cook Inlet commercial fishery[2], 276 had a missing adipose fin (A. Hoffmann, Alaska Department of Fish and Game, Anchorage, personal communication). Of these, 276 heads were removed and sent to the FRED Division CWT lab for processing. A total of 203 fish (74%) had CWT's present that could be decoded. Decodeable tags from Little Susitna River broods were from four hatchery releases: a 1990 fry release and a 1990 smolt release, and two 1991 smolt releases. Hatchery contributions were estimated separately for seven statistical weeks and summed (with each respective variance) for a total estimated hatchery contribution of 2,828 (SE = 242) fish to the northern Cook Inlet commercial harvest of which 1,355 (SE = 143) or 48% were of Little Susitna origin.

Ninety-five percent of the total 1992 estimated hatchery contribution of 1,355 Little Susitna River hatchery fish to the northern Cook Inlet commercial harvest originated from the two major 1991 smolt releases at Nancy Lake and Houston. The Nancy Lake release contributed 984 (SE = 117) or 77% and the Houston release contributed 298 (SE = 67) or 23% of the estimated total 1,282 (SE = 135) fish contributed from these two smolt releases. The remaining 5% originated from the 1990 Nancy Lake fry and smolt releases.

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[2] The set gill net fishery in the northern district of Cook Inlet.

Table 10. Little Susitna River weir coho salmon hatchery composition summary data, 1992.

Strata	Escapement Thru Weir	Number Inspected	Percent Inspected	Clips Observed	Tags Calculated[a]	Percent Hatchery[b]	Wild Fish	Hatchery Fish	SE	Relative Precision[d]
723-729	438	137	31%	1	1	0.0%	434	19	19[c]	163%
730-805	1,455	542	37%	8	7	0.5%	1,298	113	41	59%
806-812	6,331	1,026	16%	10	9	1.6%	5,826	333	109	54%
813-819	3,288	534	16%	13	12	2.1%	16,379	443	125	47%
820-826	4,222	720	17%	19	17	2.8%	1,851	597	141	39%
827-902	4,877	861	18%	26	24	3.9%	1,965	815	162	33%
903-909	529	190	36%	9	8	0.6%	2,511	133	45	56%
910-916	42	17	41%	1	1	0.0%	602	15	14[c]	153%
Totals	21,182	4,027	19%	87	79	11.5%	30,866	2,468	279[c]	19%

[a] Adjusted for tag loss (0.0866).

[b] Assumes all clips observed have a decodeable tag from the combined Nancy Lake-Houston 1991 smolt release (pr = 0.1669).

[c] Standard error of hatchery contribution estimate biased due to only one clip observed.

[d] Relative precision in numbers of fish = (1.645 * SE)/Hatchery Fish * 100%.

The estimated 1,493 (SE = 195) hatchery coho salmon in the northern Cook Inlet district commercial fishery that were not of Little Susitna River origin were from other Cook Inlet releases (Fish Creek, Crooked Creek, and Eklutna). Ninety-four percent (1,403) of these fish originated from Fish Creek releases (Hoffmann and Waltemyer *In prep*).

Estimated Hatchery Contribution:

The combined sport harvest and escapement hatchery contribution to the Little Susitna River was estimated to be 3,950 (SE = 337) coho salmon or 13.5% of the total estimated return to the river excluding those harvested by unsurveyed anglers. An additional 1,355 hatchery fish from Little Susitna River releases of Little Susitna River broods were caught in the northern district set gill net commercial fishery. Contribution of hatchery releases from the Little Susitna River were not estimated for other Cook Inlet commercial fisheries, particularly those of the central district. Contribution of wild stock Little Susitna River fish was not made for any commercial fishery.

Stocking and Egg Collection

Fish from the Nancy Lake 1991 smolt release comprised an estimated 80% of the coho salmon inspected at the egg take site. One CWT (13-01-01-04-06) from a 1990 Nancy Lake fry release was observed in the egg take (Appendix D3) while no fish from the 1991 Houston smolt release were observed.

The 1992 brood of coho salmon eggs was collected from sexually mature fish in Nancy Lake near the mouth of Lilly Creek. At an estimated 76% egg to smolt survival in the hatchery, approximately 634,000 smolt are expected to result from the 834,000 eggs taken in 1992. Approximately 300,000 smolt will be released into the Little Susitna River in 1994. The remainder will be utilized in other stocking programs. A minimum of 30,000 Little Susitna River released smolt (10%) will be tagged prior to release.

DISCUSSION

The 1992 coho salmon sport fishing season (mid-July through early September) was the second season in which the Little Susitna River was managed according to the Little Susitna River coho salmon management plan. This plan requires the escapement of at least 7,500 nonhatchery coho salmon to the mainstem river upstream of the Parks Highway bridge. A one coho salmon bag limit was also in effect until 6 August during the 1991 and 1992 calendar years. Previous researchers (Bartlett and Vincent-Lang 1989, Bartlett and Sonnichsen 1990, Bartlett and Bingham 1991, Bartlett 1992) observed a separation in the proportional timing of hatchery and nonhatchery stocks with the majority of the hatchery stock entering the river later in the season. The bag and possession limit prior to 6 August of one coho salmon was an effort to preserve the earlier timing of nonhatchery stock.

The proportional escapement timing of the nonhatchery stock and the hatchery stock in 1992 was again temporally separated suggesting that the intent of the 1990 management plan as a mechanism to preserve the natural timing of the nonhatchery stock was successful (Figure 3). The overall timing and the mid-point of the cumulative escapement of mixed stocks since 1988 also appears to

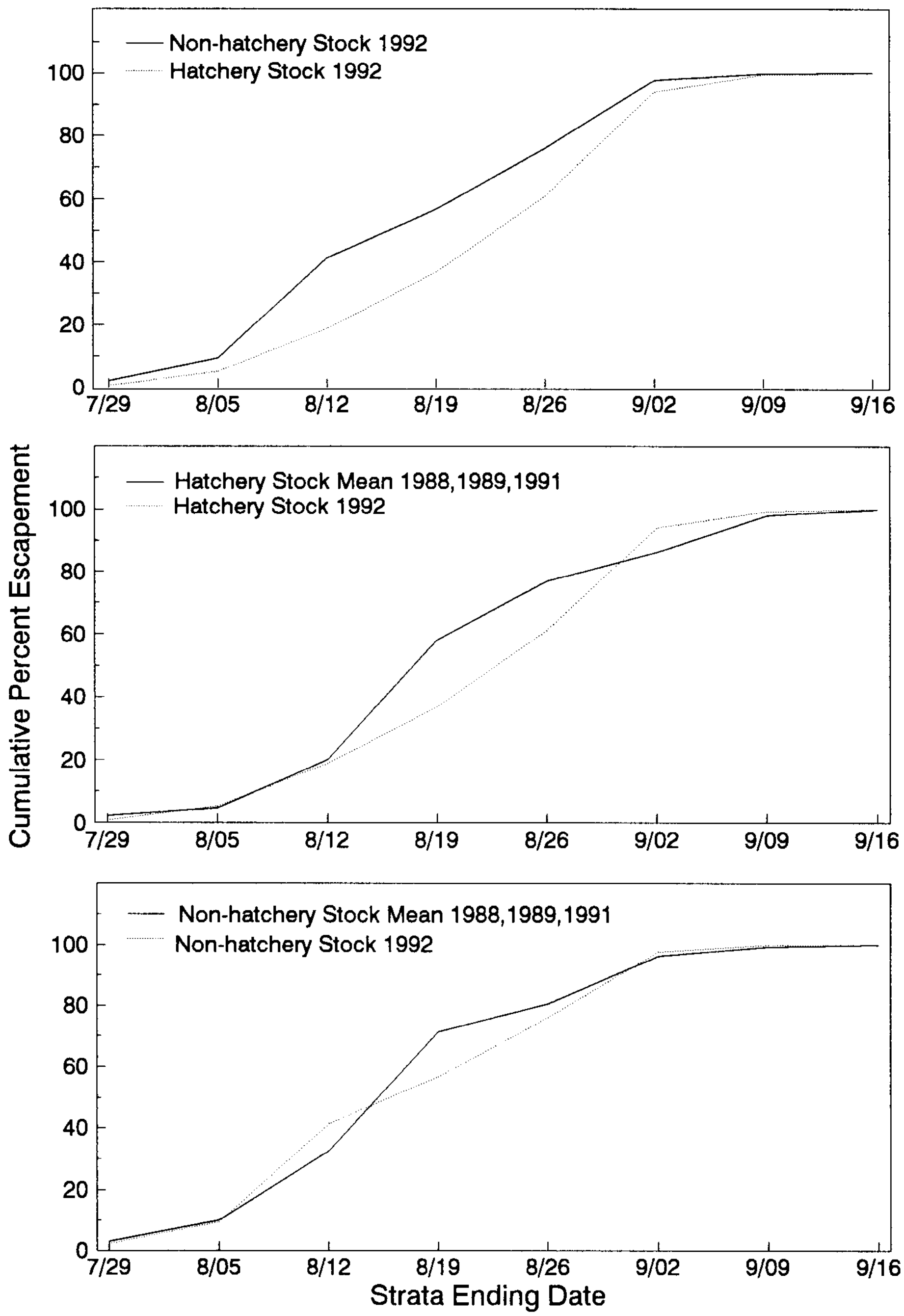

Figure 3. Proportion of timing of estimated 1992 and 1988-1989 and 1991 hatchery and non-hatchery coho salmon stocks through the Little Susitna River weir (rkm 52).

occur within ± 3 days from 16 August (Bartlett and Vincent-Lang 1989, Bartlett and Sonnichsen 1990, Bartlett and Bingham 1991, Bartlett 1992, and Figure 2 of this report).

Projection of the escapement goal of 7,500 nonhatchery coho salmon upstream of the Parks Highway bridge (rkm 112) can signal an increase in the bag limit downstream of the weir (and within a 0.4 km radius of the confluence of Nancy Lake Creek with the Little Susitna River) from three to five fish. The nonhatchery escapement goal has been estimated for the past 2 years the management plan has been in place. During both years the goal was met on 13 August and the bag limit increased by emergency order shortly afterward (Figure 5 in Bartlett 1992 and Figure 4 of this report). Overall, approximately twice as many fish were harvested during the three fish bag limit than were harvested during the five fish bag limit (Figure 5). Even with the harvest being approximately two fold during the three fish bag limit, approximately 700 hatchery fish were harvested during the three fish bag limit while approximately 900 hatchery fish were harvested during the five fish bag limit. The increase in the percent harvest of hatchery fish during the five fish bag limit shows the timing of the emergency order to be on target to assist the harvest of the relative higher abundance of hatchery fish later in the run.

A relatively high catch and release mortality of coho salmon in the intertidal waters of the Little Susitna River during the one coho salmon bag limit (through 5 August) was again observed during the 1992 season (Table 3 of this report and Table 5 in Bartlett 1992). The mortality estimate is based on studies by Vincent-Lang et al. (*In press*) which indicate the mortality of hooked and released coho salmon in the intertidal waters of the Little Susitna River is as high as 69%. This mortality in the intertidal waters is attributed by Vincent-Lang et al. (*In press*) chiefly to hooking in the gills or gullet and associated bleeding. Bait was the only terminal gear used during the study and hooking in these areas of the fish are common when using bait.

In 1989, 82% of boat anglers used bait and another 14% used some combination of bait and lures (Bartlett and Sonnichsen 1990). The type of gear used by boat anglers was not recorded during the 1992 creel survey, but by observations on the river there are no reasons to believe that the percent of boat anglers using bait in the turbid, intertidal water of the Little Susitna River has change appreciably from 1989.

Some of the hooking mortality estimated in Table 3 (and in Table 5 in Bartlett 1992) was visible in the Little Susitna River. In 1991 and in 1992, small numbers of dying hooked and released (or hooked and escaped) coho salmon were highly visible between the Burma Road landing area and the weir during periods of clear water (Figure 1). They also washed back on the weir in uncounted numbers. Some of these fish were recovered and examined. Almost all those examined had hooks imbedded in the gills or gullet; or visible injury to the gills and or gullet. Necropsy almost always revealed hemorrhaging as the probable cause of death. These fish, although relatively few in number (estimated to have been between 50 to 100 fish from 16 July through 2 September), are only a small portion of the total estimated hook and release mortality.

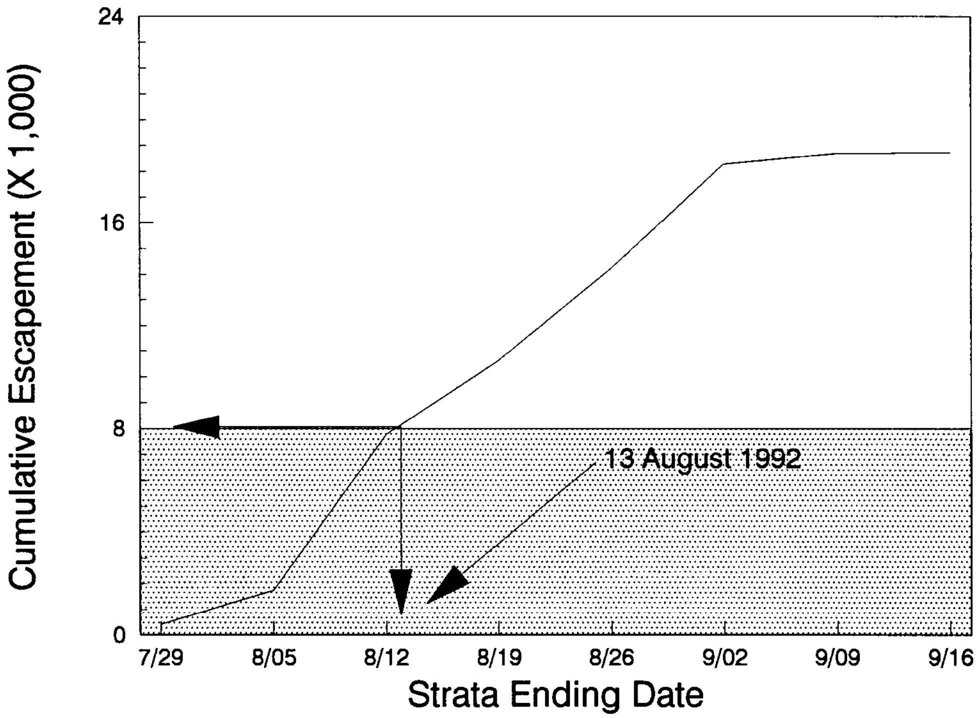

Figure 4. Estimated cumulative escapement of non-hatchery coho salmon through the Little Susitna River weir (rkm 52) in 1992 with the escapement goal of 7,500 (+ 500 to compensate for upstream harvest) coho salmon noted.

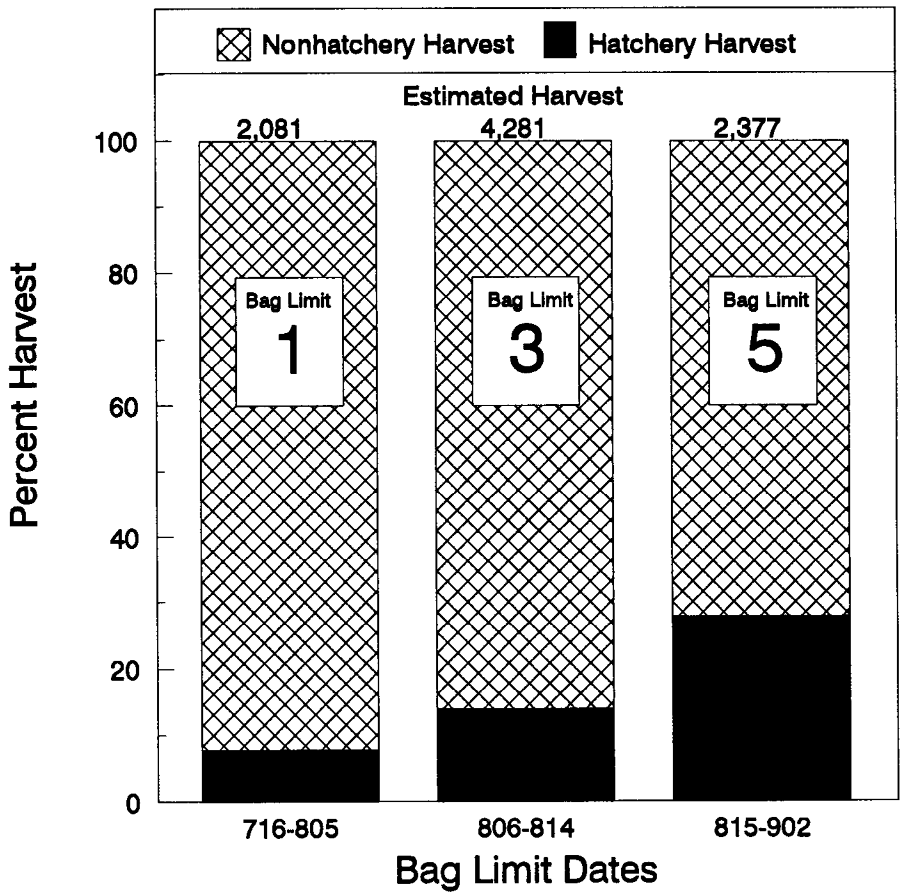

Figure 5. Percent harvest of nonhatchery and hatchery Little Susitna River coho salmon by bag limit period of boat anglers exiting the sport fishery through the Burma Road boat landing during 1992. The five fish bag limit applies to downstream of the weir (rkm 52) only.

In an attempt to mitigate the hook and release mortality, or to increase harvest opportunity on the Little Susitna River, a proposal to return to the pre-1991 three-fish bag limit and prohibit the use of bait downstream of the Parks Highway bridge (i.e., allow the use of artificial lures only) from 15 July through 5 August annually was adopted by the Board of Fisheries as regulation in November of 1992. This regulation went into effect on 1 January 1993.

Catch rates by gear type have not been estimated in past reports making the probable impact of this new regulation in terms of overall gear efficiency only speculative. The initial impact of the new regulation is expected to be a reduction in the catch rates as anglers learn new techniques and areas to fish. Eventually the catch rates will most likely increase although probably not to the level observed in the current and predominantly bait fishery. However, it is expected that the total mortality (Table 3) may approach current levels over time; the difference being that a large portion of the now hook and release mortality will shift to the harvest.

The percent estimated hatchery contribution to the harvest and the escapement in 1992 was the lowest on record since 1986 (Table 11). This observation should not be of great concern unless the trend continues sharply downward for the next few years. As shown in Table 11, there is considerable variation in the estimated hatchery contributions between years. The variability between the years can have wide-ranging causes from brood stock genetics, hatchery practices, and freshwater survival through unknown factors related to ocean rearing. Open ocean (high seas) and nearshore commercial fishing are also possible factors affecting the annual inriver hatchery contribution.

The contribution of hatchery fish estimated through 1992 CWT recovery program in the northern Cook Inlet district commercial fishery suggests that this fishery was a factor to consider in 1992. The estimated 1992 hatchery contribution of Little Susitna River fish to this commercial fishery equaled the estimated hatchery contribution to the Burma Road boat angler sport harvest. Even though 1992 was the first year the contribution of hatchery fish of Little Susitna River origin was estimated in the northern district commercial fishery, it would seem reasonable that this commercial fishery has impacted the return of hatchery fish, to varying degrees, since the inception of the stocking program in the Little Susitna River. The Cook Inlet southern and central district commercial fisheries, and adjacent nearshore commercial fisheries would add, in varying numbers, to the total number of Little Susitna River coho salmon taken in the commercial fisheries. The contributions of hatchery fish to these commercial fisheries are currently not estimated.

Of interest is the observation that the ratio of Nancy Lake to Houston CWT's was nearly equal in both the sport (78% and 22%) and commercial (77% and 23%) harvests. This observation suggests that the fish were returning in the proportions observed in the sport harvest prior to entering the river. Comparatively, the proportion of fish stocked at these two locations was 68% at Nancy Lake versus 32% at Houston. If unestimated proportional contribution levels to the escapement were similar to those observed in the two surveyed fisheries, then it would appear that the return strength of the Houston stocked fish was less than for the Nancy Lake fish.

Table 11. Contribution of hatchery-origin coho salmon to the estimated sport harvest and escapement past the Little Susitna River weir from 1986 through 1992.

	Total[a]		Hatchery[a]		
Year	Estimate	SE	Estimate	SE	Percent[b]
Harvest:					
1986	5,812	--[c]	107	30.5	1.8
1987	13,202	442.1	3,460	509.7	26.2 ± 7.8
1988	12,759	405.0	6,468	571.9	50.7 ± 9.3
1989	14,150	746.3	10,660	1,275.2	75.0 ± 19.3
1990	8,001	866.8	2,393	478.0	29.9 ± 13.3
1991	14,079	1,297.0	6,584	1,205.7	46.8 ± 18.8
1992	8,739	674.0	1,482	188.7	17.0 ± 4.9
Escapement:					
1986[d]					
1987[e]					
1988	21,438	--[f]	4,764	1,076.3	22.2 ± 9.8
1989	15,855	--[f]	7,191	757.6	45.9 ± 9.4
1990	15,511	--[f]	3,791	449.0	24.4 ± 5.7
1991	39,241	--[f]	8,375	592.9	21.4 ± 3.0
1992	21,182	--[f]	2,468	279.0	11.5 ± 2.6

[a] 1986 through 1990 data were taken from Federal Aid annual reports.

[b] ± figures after percentage indicates the 90% absolute precision levels for the reported percentages.

[c] Standard error not reported.

[d] No tagged fish reported.

[e] No weir in place.

[f] Measured without error.

Returning hatchery fish are almost exclusively age 1.1 while the nonhatchery stock is mixed age 1.1 and 2.1. Estimation of the ratio of age-1.1 to age-2.1 nonhatchery fish in the escapement was not possible because of the presence of unmarked age-1.1 hatchery fish in the age sample. Only one pure, nonhatchery age sample from the Little Susitna River coho escapement is known to exist (Bartlett and Bingham 1991). This 1978 sample was comprised of 42% age-1.1 and 57% age-2.1 fish. Based on this one sample it would seem that the nonhatchery escapement could be comprised of up to roughly one half age-1.1 fish. The number of age-1.1 fish (230) in the escapement age sample minus an estimated hatchery contribution of 11.5% (25) divided by the total fish in the sample (448) suggests the number of nonhatchery age-1.1 fish in the escapement age sample was roughly 46% (204 fish). This approximates the split by age of 42% age 1.1 and 57% age 2.1 in pre-hatchery Little Susitna coho salmon stock as reported by Bartlett and Bingham (1991) to some degree.

The percent hatchery contribution to the sport harvest since 1988 has been higher in magnitude than in the escapement (Table 11). Age-1.1 fish from the 1992 mixed-stock age samples also dominated the sport harvest (312 versus 147 fish); while age 1.1 and 2.1 (230 versus 218) were nearly equivalent in the escapement samples. The reason the contribution of hatchery fish (age-1.1 fish) has been consistently greater in the sport harvest versus the escapement is unknown and speculative (Bartlett 1992) but the observation is supported by the dominance of age-1.1 fish in the 1992 sport harvest age sample.

Coho salmon smolt have been stocked in the mainstem Little Susitna River at Houston since 1989. The intent of the Houston release was to provide a return of fish to the Houston area (L. E. Engel, retired Alaska Department of Fish and Game, Palmer, personal communication). This intent has evidently not been realized in any of the returns since the stocking began as adult coho salmon have not been observed to return to the vicinity of the Houston release site. Returning fish from the Houston releases are thought to continue upstream where they compete with the nonhatchery stock for spawning space and partners.

It has not been documented but some mixing of the Nancy Lake released hatchery stock with the then wild (now nonhatchery) spawning stock in the upper mainstem river prior to the Houston releases must have occurred. However, this potential early mixing would have been very small when compared to the magnitude it is now assumed to be with returns from the Houston stocking. Considering the possibility of unknown problems associated with the genetic dilution of wild stocks with hatchery fish, continuation of the Houston release should be evaluated.

A goal of all hatchery enhancement programs is, or should be, to maintain the quality of returning hatchery and nonhatchery fish after the stocking of hatchery fish. Quality is a subjective term which can have several different meanings. In terms of coho salmon, quality to the majority of Little Susitna River anglers means a fresh-run fish of average or larger than average length for that particular genetic stock. The mean lengths of 1992 Little Susitna River mixed hatchery and nonhatchery fish from the sport harvest sample were statistically compared by sex to samples of similar size from the 1983 sport harvest of wild Little Susitna River coho salmon. The mean lengths by sex of the 1992 coho salmon appear not to have changed significantly from the 1983 coho salmon, suggesting that the hatchery enhancement of coho salmon in the

Little Susitna River has not affected this measure (length) of angler perceived quality.

Recommendations

Based on the data contained in this report and discussion, we recommend the following:

1. At the close of the 1994 season, compile and summarize the history and results of all aspects of the enhancement program in one document. Use this document as a basis for evaluating the future direction of the program. This recommendation was previously identified (Bartlett 1992).

2. Kill all sampled coho salmon with a missing adipose fin at the weir during the 1993 return (similar procedures in 1992 would have resulted in a kill of only 87 fish). Recovery of CWT's should provide a more accurate estimate of the contribution from the respective releases expected to return. A similar recommendation was previously identified (Bartlett 1992).

3. Promote the harvest of returning hatchery coho salmon in Nancy Lake. These fish may not be the best quality but some people would gladly harvest them if they were made aware the fish are present. As it is now, several hundred are used in the egg take, several hundred ascend Lilly Creek to spawn naturally, and the remainder die unspawned near the creek mouth. A similar recommendation was previously identified (Bartlett 1992).

4. Reevaluate the reason for releasing smolt at Houston. It appears that these fish are not accomplishing the intent of providing fish to harvest in the Houston area, and it appears that returns from fish stocked at this location perform poorly compared to the Nancy Lake site releases. Accordingly, more opportunity to harvest fish in sport fisheries would accrue from stocking all the fish in the Nancy Lake site, assuming a better return strength.

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APPENDIX A

Appendix A1. Definition of sampling strata for the 1992 Little Susitna River creel survey of the Burma Road boat angler fishery.

Week[a]	Stratum	Date	Number of Days Per Stratum	Number of Days Sampled	Number of Periods Per Day	Number of Periods Sampled Per Day
1	1	16 - 22 July	7	4	5	2
2	2	23-29 July	7	4	5	2
3 WD	3	30-31 July and 3-5 August	5	2	5	2
WE	4	1-2 August	2	2	5	2,3[b]
4 WD	5	6-7 and 10-12 August	5	5	5	2,2,3,3,2[b]
WE	6	8-9 August	2	2	5	3
5 WD	7	13-14 and 17-19 August	5	5	5	2
WE	8	15-16 August	2	2	5	3
6 WD	9	20-21 and 24-26 August	5	3	4	2
WE	10	22-23 August	2	2	4	2
7	11	27 August - 2 September	7	4	3	2

[a] WD denotes weekday; WE denotes weekend.

[b] Multiple listing of periods indicate the number of periods sampled within each day for each day sampled within noted stratum.

Appendix A2. Definition of sampling periods within days for the 1992 Little Susitna River creel survey of the Burma Road boat angler fishery.

Weeks	Strata	Time of Season	Sample Period	Time of Day
1-5	1-8	16 July to 19 August	A	0400-0759
			B	0800-1159
			C	1200-1559
			D	1600-1959
			E	2000-2359
6	9-10	20 August to 26 August	A	0500-0859
			B	0900-1259
			C	1300-1659
			D	1700-2059
7	11	27 August to 2 September	A	0700-1059
			B	1100-1459
			C	1500-1859

Appendix A3. Estimation equations for angler effort for, and catch and harvest of, coho salmon in the 1992 Burma Road boat angler sport fishery in Little Susitna River.

The following procedures were used to estimate effort, catch, and harvest in the 1992 survey. The procedures as outlined below represent a 3-stage direct expansion estimation approach. This approach involved the direct expansion of sampled interview data by expansion factors dependent upon the number of anglers counted (third-stage units), sample periods (second-stage units), and days (first-stage units). Since all anglers counted were interviewed, the design collapsed to a 2-stage design, however estimates were still obtained in a 3-stage manner (and were equivalent).

First the mean angler effort over all completed-trip anglers interviewed within a sampled period was obtained:

$$\bar{e}_{hij} = \frac{\sum_{k=1}^{m_{hij}} e_{hijk}}{m_{hij}}; \qquad \text{(A3.1)}$$

where: m_{hij} equals the number of anglers interviewed during sample period *j* during day *i* within stratum *h*; and e_{hijk} equals the effort in hours expended by each angler interviewed.

Next, the number of third-stage units (anglers counted) was used to expand this mean to obtain the estimated angler effort for each sample:

$$\hat{E}_{hij} = M_{hij}\,\bar{e}_{hij} \qquad \text{(A3.2)}$$

where: M_{hij} equals the number of anglers counted during each sample period (note that this number equals m_{hij} for this survey).

Next the mean effort across periods sampled within each day was calculated:

$$\bar{\hat{E}}_{hi} = \frac{\sum_{j=1}^{p_{hi}} \hat{E}_{hij}}{p_{hi}}; \qquad \text{(A3.3)}$$

where: p_{hi} equals the number of periods sampled within each day.

-continued-

The estimated angler effort for each day was then obtained as:

$$\hat{E}_{hi} = P_{hi}\,\bar{\hat{E}}_{hi}\ ; \tag{A3.4}$$

where: P_{hi} equals the number of sampling periods in the day.

Then the mean effort across days sampled within each stratum was estimated by:

$$\bar{\hat{E}}_{h} = \frac{\sum_{i=1}^{d_h} \hat{E}_{hi}}{d_h}\ ; \tag{A3.5}$$

where: d_h equals the number of days sampled within each stratum.

Finally, this mean daily value was expanded by the number of days in each stratum (i.e., D_h) to obtain the stratum estimate of angler effort:

$$\hat{E}_{h} = D_h\,\bar{\hat{E}}_{h}\ . \tag{A3.6}$$

The variance for the estimated angler effort for each stratum was obtained by the three-stage variance equation (adapted from the approach outlined in: Cochran 1977, equation 11.24, page 303):

$$\hat{V}[\hat{E}_h] = \left[(1 - f_{1h})\frac{D_h^2}{d_h} s_{1h}^2\right] + \left[f_{1h}\frac{D_h^2}{d_h^2}\sum_{i=1}^{d_h}(1 - f_{2hi})\frac{P_{hi}^2}{p_{hi}} s_{2hi}^2\right] + \left[f_{1h}\frac{D_h^2}{d_h^2}\sum_{i=1}^{d_h} f_{2hi}\frac{P_{hi}^2}{p_{hi}^2}\sum_{j=1}^{p_{hi}}(1 - f_{3hij})\frac{M_{hij}^2}{m_{hij}} s_{3hij}^2\right] \tag{A3.7}$$

where: f_{1h}, f_{2hi}, and f_{3hij} are the sampling fractions for the first, second, and third sampling stages, respectively (i.e., $f_{1h} = d_h / D_h$, $f_{2hi} = p_{hi} / P_{hi}$, and $f_{3hij} = m_{hij} / M_{hij}$);

-continued-

S^2_{1h} = the among day variance for the total effort estimate;

$$= \frac{\sum_{i=1}^{d_h} (\hat{E}_{hi} - \bar{\hat{E}}_h)^2}{d_h - 1}; \qquad \text{(A3.8)}$$

S^2_{2hi} = the among period variance for each day sampled;

$$= \frac{\sum_{i=1}^{p_{hi}} (\hat{E}_{hij} - \bar{\hat{E}}_{hi})^2}{p_{hi} - 1}; \text{ and} \qquad \text{(A3.9)}$$

s^2_{3hij} = the within sample variance for the effort estimate observed over all anglers interviewed during each sampled period;

$$= \frac{\sum_{j=1}^{m_{hij}} (e_{hijk} - \bar{e}_{hij})^2}{m_{hij} - 1}. \qquad \text{(A3.10)}$$

Note, that since all anglers were expected to be interviewed in these surveys, then all $f_{3hij} = 1$, and the third major term in equation A3.7 is equal to zero.

Estimates of catch and harvest of coho salmon and their variances were estimated similarly, by substituting the appropriate catch or harvest statistics in place of angler effort in equations A3.1 through A3.10, above.

Total angler effort, catch, or harvest across all strata (or select combinations of strata) and the associated variances were obtained by summing the corresponding stratum estimates (assuming independence). Standard errors were obtained by taking the square root of the variance estimates.

APPENDIX B

Appendix B. Summary information collected and recorded at the Little Susitna River coho salmon weir, 1992.

The following summary information was collected at the Little Susitna River coho salmon weir and called in daily to the Palmer office.

1. The number of coho salmon passed upstream of the weir (the number of coho salmon observed to pass back over the weir after release were subtracted from the daily count of adult salmon passing through the weir and continuing upstream);

2. the number of coho salmon passed over the weir during boat passage;

3. the number of coho salmon examined for a missing adipose fin;

4. the number of coho salmon observed to have a missing adipose fin;

5. the number of coho salmon sampled for age and sex composition at the weir; and

6. any other pertinent factors that may have affected the efficiency of the weir to accurately census the passage of coho salmon upstream of rkm 52.

APPENDIX C

Appendix C. Estimation equations for the age composition in proportions and in numbers for the fish harvested in the Burma Road boat angler coho salmon sport fishery and the escapement through the weir (rkm 52), in the Little Susitna River, 1992.

Estimates of the proportion and apportioned abundance of coho salmon by sex and age class, were calculated with the sampling strata grouped into temporal components or strata to describe 7-day periods in the fishery. The first step in obtaining these estimates was to calculate the proportions of each age class of fish harvested in each stratum of the sport fishery or the escapement through the weir:

$\hat{p}_{uh}$ = estimated proportion of the sampled coho salmon harvested or in the spawning escapement samples that are age *u* within each stratum[1] or combined strata;

$$= \frac{n_{uh}}{n_h}; \qquad \text{(C.1)}$$

where: n_{uh} equals the number of the sampled coho salmon either harvested within each stratum or combined strata for the creel surveys or the number sampled from the escapement that are age *u*; and n_h equals the total number of coho salmon sampled within each creel survey or escapement stratum or combined strata.

The variance of the estimated proportion of coho salmon harvested or in the escapement is estimated approximately by the standard equation for the variance of a binomial proportion (Cochran 1977, equation 3.8, page 52) (where the first term on the right-hand-side of the ≈ sign is for the harvest survey and the second term, after the "or" is for the escapement-weir survey):

$$\hat{V}[\hat{p}_{uh}] \approx \left(1 - \frac{n_h}{\hat{H}_h}\right) \frac{p_{uh}(1 - p_{uh})}{n_h - 1} \text{ or } \left(1 - \frac{n_h}{N_h}\right) \frac{p_{uh}(1 - p_{uh})}{n_h - 1}. \qquad \text{(C.2)}$$

where: $\hat{H}_h$ equals the estimated harvest of coho salmon in each stratum or combined strata, obtained from equation A3.6; and N_h equals the number of coho salmon counted past the weir during each weir stratum or combined strata period.

-continued-

[1] Stratum refers to the sampling strata associated with the creel surveys for the harvest age composition estimates. The escapement sampling program is also stratified by 7-day periods, matching up to the creel survey periods.

The estimated proportion by age class (across all strata or across combined strata) was obtained by first estimating the number of coho salmon by age class in each stratum or combined strata:

$\hat{N}_{uh}$ = estimated number of fish harvested which are age class *u*, within stratum *h* (with the first term for the creel survey and the second term for the escapement-weir survey);

$$= \hat{H}_h \, \hat{p}_{uh} \quad \text{or} \quad N_h \, \hat{p}_{uh} \, . \qquad \text{(C.3)}$$

The variance of the estimated number of fish harvested which are age class *u*, within stratum *h*, was obtained by Goodman's (1960) equation for the variance of the product of two random variates:

$$\hat{V}[\hat{N}_{uh}] = \hat{H}_h^2 \, \hat{V}[\hat{p}_{uh}] + \hat{p}_{uh}^2 \, \hat{V}[\hat{H}_h] - \hat{V}[\hat{p}_{uh}] \, \hat{V}[\hat{H}_h] \; ; \qquad \text{(C.4a)}$$

where: $\hat{V}[\hat{H}_h]$ equals the variance of the estimated harvest for each stratum, obtained by equation A3.7.

The variance of the estimated number of fish in the escapement past the weir which are age class *u*, within stratum *h*, was obtained simply by the usual equation for the product of a constant and a random variate:

$$\hat{V}[\hat{N}_{uh}] = N_h^2 \, \hat{V}[\hat{p}_{uh}] \, . \qquad \text{(C.4b)}$$

Next the number of fish in the harvest or in the escapement in each age class over all strata was obtained by summing the numbers across strata:

$$\hat{N}_u = \sum_{h=1}^{s} \hat{N}_{uh} \, . \qquad \text{(C.5)}$$

The variance of the estimated number of each age fish in the harvest or in the escapement was obtained by summing the corresponding variances (assuming independence, see Kish 1965, equation 2.8.7, page 61). Finally, the proportion of each age class across all strata was obtained as follows (with the first term for the harvest survey and the second term for the escapement-weir survey):

$$\hat{p}_u = \frac{\hat{N}_u}{\hat{H}} \quad \text{or} \quad \frac{\hat{N}_u}{N} \; ; \qquad \text{(C.6)}$$

-continued-

where: $\hat{H}$ equals the estimated total abundance of coho salmon over all sex and age groupings over all strata; and N equals the total number of coho salmon counted past the weir.

The percentage of each age group was derived by multiplying the above proportions by 100%.

The variance of the estimated proportion of coho salmon in each category for the harvest survey was calculated approximately using the Delta Method (see Seber 1982, section 1.3.3, pages 7-9) by:

$$\hat{V}[\hat{p}_u] \approx \left[\frac{\hat{N}_u}{\hat{H}}\right]^2 \left[\frac{\hat{V}[\hat{N}_u]}{\hat{N}_u^2} + \frac{\hat{V}[\hat{H}]}{\hat{H}^2} - \frac{2\,\hat{V}[\hat{N}_u]}{\hat{N}_u\,\hat{H}}\right]; \qquad \text{(C.7a)}$$

The corresponding variance estimate for the escapement survey at the weir was obtained by the standard equation for a ratio of a random variate to a constant:

$$\hat{V}[\hat{p}_u] = \frac{\hat{V}[\hat{N}_u]}{N^2}. \qquad \text{(C.7b)}$$

APPENDIX D

Appendix D1. Summary of coho salmon smolt stocked in the Little Susitna River from eggs taken at Nancy Lake and incubated at Fort Richardson Hatchery from 1983-1993.

Brood Year	Number Of Eggs Incubated	Release Site	Year	Size(g)	Number	Number Marked	Tag Code	Dominant Return Year
1983	56,000	Nancy Lake	1985	17.1	54,394	12,151		1986
1984	594,000	Nancy Lake	1986	17.2	580,065	24,401	31-17-30	1987
1985	552,000	Houston	1987	19.0	98,156	7,950	31-17-45	1988
		Nancy Lake		19.2	203,011	16,700	31-17-45	
		1987 Release Year Total			301,167	24,650		
1986	495,400	Nancy Lake	1988	20.1	446,016	24,628	31-17-61	1989
1987	537,877	Houston	1989	18.5	49,349	3,581	31-18-32	1990
		Nancy Lake		20.8	305,548	22,050	31-18-32	
		1989 Release Year Total			354,897	25,631		
1988	462,000	Houston	1990	20.8	106,242	15,679	31-19-17	1991
		Nancy Lake		20.8	202,114	29,541	31-16-01	
		1990 Release Year Total			308,356	45,220		
1989	530,315	Houston	1991	23.4	88,675	16,151	31-19-36	1992
		Nancy Lake		22.9	189,087	30,207	31-19-35	
		1991 Release Year Total			277,762	46,358		
1990	590,015	Houston	1992	24.1	154,466	21,884	31-20-07	1993
		Nancy Lake		23.4	158,459	21,598	31-20-06	
		1992 Release Year Total			312,925	43,482		
1991	833,883		1993					1994
1992	833,638		1994					1995

Appendix D2. Estimation equations for the hatchery contribution of stocked coho salmon to the Burma Road boat angler coho salmon sport fishery in the Little Susitna River, 1992.

The notation used in the following equations essentially follows that used by Clark and Bernard (1987), with additional subscripts used to denote individual stratum (or combined strata). The first step involved estimating the contribution to each stratum (or combined strata) in the fishery of each particular tag code (using equation [10] from Clark and Bernard (1987):

$\hat{n}_{1Ah}$ = estimated contribution of stocked fish from release associated with unique tag code *A* for fishery stratum *h*;

$$= \left[\frac{\hat{N}_h}{n_{2h}}\right]\left[\frac{a_{1h}}{a_{2h}}\right]\left[\frac{m_{1h}}{m_{2h}}\right]\left[\frac{m_{cAh}}{\theta_A}\right]; \qquad \text{(D2.1)}$$

where: $\hat{N}_h$ equals the estimated harvest of all coho salmon within each stratum; n_{2h} is the number of coho salmon inspected for missing adipose fins from the sampled harvest in each fishery stratum; a_{1h} equals the number of coho salmon with a missing adipose fin which were counted and marked with a head strap from each stratum; a_{2h} equals the number of coho salmon heads previously marked with a a head strap which arrived at the tag lab, from fish originally sampled from stratum *h*; m_{1h} equals the number of coded wire tags which were detected in the coho salmon heads at the tag lab, from those sampled from stratum *h*; m_{2h} is the number of coded wire tags which were removed from the coho salmon heads and decoded, from coho salmon sampled from stratum *h*; m_{cAh} is the number of coded wire tags dissected out of the coho salmon heads and decoded as the unique tag code *A*, originally sampled from stratum *h*; and θ_A equals the proportion of a particular hatchery release which contains a coded wire tag of the unique tag code *A*.

Estimates of across strata (or initially combined strata) contributions by tag code, as well as by combined tag codes were obtained by summing the estimates across the strata and tag codes, as appropriate.

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Bootstrapping (Efron 1982) was used to calculate the variance of the contribution estimate. The components of variance for the contribution estimate included components from the harvest estimation procedure (i.e., the creel survey) and the harvest sampling program. Estimated harvest was considered normally distributed and its variance was calculated in closed form (see equation A3.7, hence no simulation was involved). The bootstrap resampling primarily involved estimation of the variance due to the CWT sampling program. Equation D2.1 was first divided into three components (in the following presentation subscripts denoting strata and particular tag codes were dropped):

$$N$$

$$\left[\frac{m_1}{m_2} \; \frac{a_1}{a_2} \; \frac{m_c}{n_2} \right]$$

$$\theta$$

The first component (N) was harvest as estimated from the creel survey, and the third component (θ) was obtained from the tag lab data base and was assumed to be known for the hatchery tag codes. The second component $[(m_1/m_2)(a_1/a_2)(m_c/n_2)]$ corresponds to statistics garnered through harvest sampling (and lab work); for convenience, M was defined as the result of the arithmetic operations in this second component. Each of these three components is the product of three distinct and independent programs.

The bootstrap was used to simulate the variation in the second component by resampling data from the harvest sampling program. Each fish counted in the harvest sampling program was placed into one of the following six categories depending on its progress through the program:

1. adipose fin was present, therefore head was not retained;
2. adipose fin was missing, either the head was strapped and sent to lab, but never arrived, or the head was not strapped or sent to the lab[1];
3. head arrived at lab, but contained no CWT;
4. head contained a CWT, but tag was not decoded;
5. tag was decoded, but did not carry the appropriate code; and
6. tag did carry the appropriate code.

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[1] Sometimes heads can not be cinch strapped even though an adipose finclip is detected, since anglers sometimes cut off the fish's head.

A multinomial, empirical density distribution with six cells was created with the data from the harvest sampling program. Respective to the categories above, the probabilities of drawing a single sample from this distribution were calculated from the original data as follows:

$$\frac{n_2 - a_1}{n_2} \qquad \frac{a_1 - a_2}{n_2} \qquad \frac{a_2 - m_1}{n_2} \qquad \frac{m_1 - m_2}{n_2} \qquad \frac{m_2 - m_c}{n_2} \qquad \frac{m_c}{n_2}$$

The bootstrap technique began by drawing with replacement a sample of size n_2 from the empirical distribution according to the probabilities based on the original data. Once such a sample was drawn (call it sample b), the result was tallied to obtain a new set of statistics $\{a^*_1, a^*_2, m^*_1, m^*_2, m^*_c\}_b$ and a value of M_b. A large number (say B numbers) of M_b were so generated, their values were used as an empirical distribution with mean and variance. These statistics were calculated as:

$$V[\bar{M}] = \frac{\sum_{b=1}^{B} (M_b - \bar{M})^2}{B - 1} \quad \text{with} \quad \bar{M} = \frac{\sum_{b=1}^{B} M_b}{B}. \tag{D2.2}$$

Then the variance of the contribution estimate was estimated as:

$$\hat{V}[\hat{n}_1] = \theta^{-2} (\hat{V}[\bar{M}] \hat{N}^2 + \hat{V}[\hat{N}] M^2 - \hat{V}[\bar{M}] \hat{V}[\hat{N}]) . \tag{D2.3}$$

Estimates of the variance of across strata contributions by tag code, as well as by combined tag codes were obtained by summing the variances across the strata and tag codes, as appropriate. The resulting estimates of variance were assumed to be conservative in that the covariances among contribution estimates by tag code within each sampling stratum was assumed to be negative (Clark and Bernard 1987).

Standard errors (SE's) were obtained as the square root of the appropriate variance.

Appendix D3. Little Susitna River drainage coho salmon fry release summary from 1982-1990.

Release Location	Date	Size(g)	Total Number	Number Tagged	Tag Code
Little Susitna River	6/22/82	0.4	2,950		
Nancy Lake	6/15/83	0.5	23,652	1,880	B4-07-13
	6/16/83	0.5	80,124	4,605	B4-07-13
	6/17/83	0.6	79,251	2,622	B4-07-13
	6/22/83	0.7	67,815	5,278	B4-07-13
	6/23/83	0.7	15,666	6,450	B4-07-13
	Total		266,508	20,835	B4-07-13
Nancy Lake	6/14/84	1.0	171,194	4,026	B4-14-11
	6/15/84	0.9	164,280	5,174	B4-14-11
	6/19/84	0.9	90,742	631	B4-14-11
	Total		436,047	9,831	B4-14-11
Nancy Lake	6/18/85	0.3	127,000	10,000	B4-15-08
	5/31/85	0.3	164,600		
Horseshoe Lake	6/20/85	0.3	140,000		
	6/21/85	0.3	79,000		
	6/05/85	0.3	229,600		
	6/03/85	0.3	85,000		
Crooked Lake	6/12/85	0.3	68,000		
	6/21/85	0.3	164,000		
Butterfly Lake	6/25/85	0.3	119,000		
Delyndia Lake	6/25/85	0.3	49,000		
	Total	Nancy L.	291,600	10,000	B4-15-08
		All Others	933,600		
Nancy Lake	6/26/86	1.0	211,255	10,300	B3-11-15
	6/27/86	1.0	105,015		
	Total	Nancy L.	316,270	10,300	B3-11-15

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Release Location	Date	Size(g)	Total Number	Number Tagged	Tag Code
Horseshoe Lake	5/11/88	16.4	15,725		
Horseshoe Lake	6/23/88	0.7	450,000		
Crooked Lake	7/01/88	1.0	105,000		
	7/05/88	1.3	151,000		
Nancy Lake	7/05/88	1.3	174,126	3,126	B3-02-02
	7/07/88	0.7 - 1.3	1,708,939	8,939	B3-02-02
East Papoose L	7/06/88	1.0	172,000		
West Papoose L	7/06/88	1.0	164,000		
Butterfly Lake	7/06/88	1.0	141,000		
Delyndia Lake	7/06/88	1.0	141,000		
Hock Lake	7/06/88	1.0	72,000		
Yohn Lake	7/06/88	1.0	46,000		
My Lake	7/06/88	1.0	58,000		
		Nancy L.	1,883,065	12,065	B3-02-02
		All Others	1,515,725		
	1988 Total		3,398,790		
Horseshoe Lake	7/28/89	1.4	8,400		
Horseshoe Lake	6/19/90	1.0	344,000		
Crooked Lake	6/20/90	1.0	78,000		
Nancy Lake	6/28/90	1.1	155,619	11,619	13-01-01-04-05
	7/06/90	1.5	65,305	28,305	13-01-01-04-05
	7/13/90	1.7	28,722	10,722	13-01-01-04-06
	7/23/90	2.0	223,681	21,681	13-01-01-04-06
My Lake	6/29/90	1.1	23,000		
Yohn Lake	6/29/90	1.1	26,000		
Butterfly Lake	6/29/90	1.1	90,000		
Hock Lake	6/29/90	1.1	40,000		
Delyndia Lake	6/29/90	1.1	89,000		
		Nancy L.	220,924	39,924	13-01-01-04-05
			252,403	32,403	13-01-01-04-06
		All Others	690,000		
	1990 Total		1,163,327		

APPENDIX E

Appendix E. Daily and cumulative counts by salmon species through the Little Susitna River weir, 24 July through 14 September 1992.

Date	Coho Salmon		Sockeye Salmon		Chum Salmon		Pink Salmon		Chinook Salmon	
	Daily	Cum.	Daily	Cum.	Daily	Cum.	Daily	Cum.	Daily	Cum.
24-Jul[a]	1	1	77	77	192	192	121	121	0	0
25-Jul	70	71	540	617	964	1,156	3,117	3,238	0	0
26-Jul	161	232	101	718	205	1,361	535	3,773	1	1
27-Jul	28	260	116	834	440	1,801	740	4,513	2	3
28-Jul	51	311	379	1,213	502	2,303	641	5,154	3	6
29-Jul	127	438	621	1,834	420	2,723	547	5,701	6	12
30-Jul	88	526	317	2,151	505	3,228	567	6,268	1	13
31-Jul	356	882	601	2,752	438	3,666	3,114	9,382	2	15
01-Aug	154	1,036	351	3,103	330	3,996	3,075	12,457	0	15
02-Aug	197	1,233	341	3,444	295	4,291	2,658	15,115	2	17
03-Aug	76	1,309	168	3,612	125	4,416	755	15,870	10	27
04-Aug	379	1,688	213	3,825	223	4,639	1,649	17,519	1	28
05-Aug	205	1,893	75	3,900	435	5,074	599	18,118	3	31
06-Aug	1,242	3,135	107	4,007	388	5,462	1,023	19,141	2	33
07-Aug	1,529	4,664	200	4,207	506	5,968	2,188	21,329	1	34
08-Aug	981	5,645	125	4,332	369	6,337	1,921	23,250	0	34
09-Aug	1,635	7,280	110	4,442	365	6,702	1,340	24,590	0	34
10-Aug	756	8,036	94	4,536	143	6,845	351	24,941	1	35
11-Aug	82	8,118	20	4,556	107	6,952	115	25,056	0	35
12-Aug	106	8,224	25	4,581	159	7,111	190	25,246	0	35
13-Aug	487	8,711	35	4,616	140	7,251	338	25,584	0	35
14-Aug	179	8,890	38	4,654	165	7,416	316	25,900	0	35
15-Aug	167	9,057	17	4,671	81	7,497	336	26,236	0	35
16-Aug	184	9,241	28	4,699	113	7,610	388	26,624	0	35
17-Aug	552	9,793	18	4,717	112	7,722	164	26,788	0	35
18-Aug	308	10,101	11	4,728	70	7,792	53	26,841	0	35
19-Aug	1,411	11,512	10	4,738	162	7,954	69	26,910	0	35
20-Aug	1,038	12,550	25	4,763	82	8,036	34	26,944	0	35
21-Aug	509	13,059	19	4,782	43	8,079	22	26,966	0	35
22-Aug	244	13,303	6	4,788	31	8,110	26	26,992	0	35
23-Aug	551	13,854	4	4,792	47	8,157	25	27,017	0	35
24-Aug	602	14,456	5	4,797	30	8,187	5	27,022	0	35
25-Aug	599	15,055	0	4,797	36	8,223	7	27,029	0	35
26-Aug	679	15,734	4	4,801	25	8,248	9	27,038	0	35
27-Aug	191	15,925	0	4,801	13	8,261	5	27,043	0	35
28-Aug	588	16,513	2	4,803	13	8,274	4	27,047	0	35
29-Aug	376	16,889	1	4,804	14	8,288	3	27,050	0	35
30-Aug	623	17,512	1	4,805	13	8,301	6	27,056	0	35
31-Aug	884	18,396	0	4,805	7	8,308	1	27,057	0	35

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Appendix E. (Page 2 of 2).

Date	Coho Salmon		Sockeye Salmon		Chum Salmon		Pink Salmon		Chinook Salmon	
	Daily	Cum.	Daily	Cum.	Daily	Cum.	Daily	Cum.	Daily	Cum.
01-Sep	1,686	20,082	3	4,808	7	8,315	3	27,060	0	35
02-Sep	529	20,611	3	4,811	5	8,320	1	27,061	0	35
03-Sep	84	20,695	5	4,816	1	8,321	0	27,061	0	35
04-Sep	80	20,775	0	4,816	5	8,326	1	27,062	0	35
05-Sep	27	20,802	2	4,818	3	8,329	2	27,064	0	35
06-Sep	84	20,886	0	4,818	1	8,330	0	27,064	0	35
07-Sep	101	20,987	0	4,818	4	8,334	1	27,065	0	35
08-Sep	101	21,088	2	4,820	1	8,335	0	27,065	0	35
09-Sep	52	21,140	5	4,825	1	8,336	0	27,065	0	35
10-Sep	11	21,151	0	4,825	0	8,336	0	27,065	0	35
11-Sep	20	21,171	0	4,825	4	8,340	1	27,066	0	35
12-Sep	11	21,182	2	4,827	2	8,342	0	27,066	0	35
13-Sep[b]	0	21,182	0	4,827	0	8,342	0	27,066	0	35

[a] Weir in place and fish tight on 24 July 1992.

[b] Weir removed on 14 September 1992.

APPENDIX F

Appendix F. Computer data files and analysis programs developed for the coho salmon creel survey and escapement studies on the Little Susitna River, 1992.

Data Files[a]

K004BSX2.DTA	Burma Road angler interview data file for anglers fishing upstream of the ADF&G weir;
K004BSY2.DTA	Burma Road angler interview data file for anglers fishing downstream of the ADF&G weir;
K004BSZ2.DTA	Burma Road angler interview data file for all anglers;
K004BCX2.DTA	Burma Road angler count data file for anglers fishing upstream of the ADF&G weir;[b]
K004BCY2.DTA	Burma Road angler count data file for anglers fishing downstream of the ADF&G weir;[b]
K004BCZ2.DTA	Burma Road angler count data file for all anglers;[b]
K004DBA2.DTA	Weir site biological data file;
K004BBA2.DTA	Creel survey at Burma Road boat launch biological data file;

Analysis Programs[c]

LSU.EXE	Research and Technical Services (RTS) program for preprocessing Burma road boat launch mark-sense angler interview data files;
UCSP92.EXE	RTS program to analyze raw data files from direct-expansion and roving creel surveys and generate estimates of angler effort, catch, and harvest;
DRA31LSU.RD	RTS report descriptive file for stage 1 of a stratified-random, three-stage, direct-expansion creel survey;
DRA32LSU.RD	RTS report descriptive file for stage 2 of a stratified-random, three-stage, direct-expansion creel survey;
DRA33LSU.RD	RTS report descriptive file for stage 3 of a stratified-random, three-stage, direct-expansion creel survey;
SFXTAB.EXE	RTS program used to cross-tabulate biological data files and produce either "discrete" or "continuous" tables of age, sex, length, and weight data;
MENU91.BAT	Series of RTS programs used to generate listing, frequency, and litho code reports from raw data;
LSU92CPU.SAS	SAS® System program used to estimate CPUE as index of abundance;
LSUBSS92.WK1	Lotus 1-2-3® worksheet used to apportion coho salmon harvest estimates by sex and age, within and across all temporal components;
LSUWSS92.WK1	Lotus 1-2-3® worksheet used to apportion coho salmon weir escapement estimates by sex and age, within and across all temporal components.

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a Data files are archived with the Alaska Department of Fish and Game, Sport Fish Division, Research and Technical Services Unit, 333 Raspberry Road, Anchorage, Alaska 99518. Contact Gail Heineman or Donna Buchholz (267-2369) for copies of the files and descriptions of the file format.

b Angler count files only contain dummy records for each date and period sampled (number of anglers interviewed from interview files equals the number of exiting anglers).

c Analysis programs are maintained by the Alaska Department of Fish and Game, Sport Fish Division, Research and Technical Services Unit, 333 Raspberry Road, Anchorage, Alaska 99518. Contact Allen Bingham or Keith Webster (267-2369) for copies of the programs.